Hybrid Systems of $Al/AlO_x/Al$ Tunnel Junctions Coupled to Semiconductor Heterostructures, I

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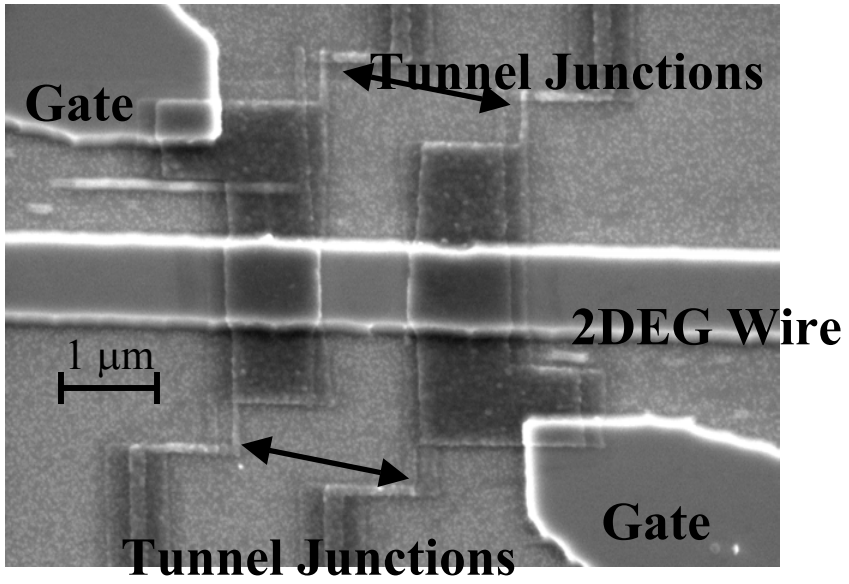

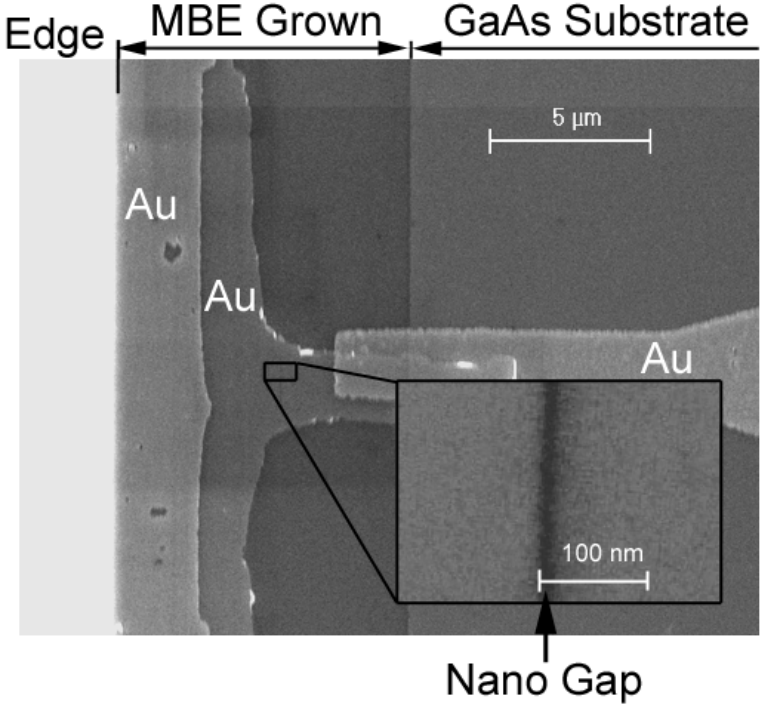

We integrate single electron transistors (SETs) with GaAs/AlGaAs heterostructures for a variety of experiments. A typical sample structure in which SETs are integrated to a quantum wire is shown on the left. In addition to our standard $Al/AlO_x/Al$ based SETs we have developed a new technique based on selective etching of GaAs/AlGaAs heterostructures which would allow us to make single electron devices that can operate at room temperature. In this technique, we first fabricate electrodes with a few nm gap and link them using an electrostatic trapping technique. The picture of the electrodes with a nanogap are shown on the right. [Proc. of Third IEEE Conf. on Nanotechnology, Vol 2, 599, (2003)]

Single electron transistors are unique devices with a charge sensitivity many orders of magnitude higher than conventional transistor. For low temperature experiments SETs are typically fabricated using electron beam lithography and made out of metallic islands that are about a micron in size (Figure on the right). To increase the operation temperature of SETs we must decrease the size of the metallic islands down to a few nanometers. To realize such nanoscale devices we have developed a novel fabrication technique based on selective etching of a GaAs/AlGaAs heterostructure. Nanogap electrodes fabricated using this technique are shown on the right. The spacing between the electrodes is about 5 nm. This is an important accomplishment; this technique will not only allow us to make SETs but also can enable us to study electrical properties of individual molecules.

Hybrid Systems of $Al/AlO_x/Al$ Tunnel Junctions Coupled to Semiconductor Heterostructures, II

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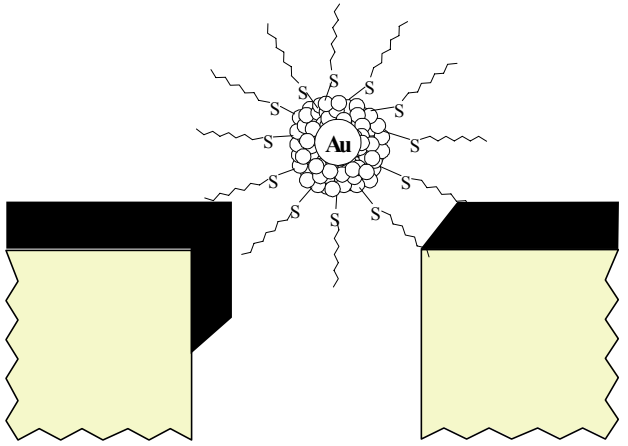

Educational:
2 graduate students
1 undergraduate student

Two graduate students, Lee Farina and Kim. M. Lewis and an undergraduate Amy Kuo contributed to these projects. Kim M. Lewis just completed her PhD thesis and will join Louisiana State University as a research associate.

We continue to run our educational web site for the Magnetic North Pole Project, a nationwide project for high school students (http://research.physics.lsa.umich.edu/northpole/).

Broader Impact:
The single electron transistor fabricated by the selective etching technique can also be used as a gas/vapor sensor with a single molecule sensitivity. Schematic diagram of such a sensor is shown above.

In addition to training graduate and undergraduste students, we have a nationwide activity in which high school students across the country do measurements to determine the position of the magnetic North pole. On our web site we provide information to hjgh school students on magnetic north pole. We also provide lesson plans to high school teachers who register at our web site.